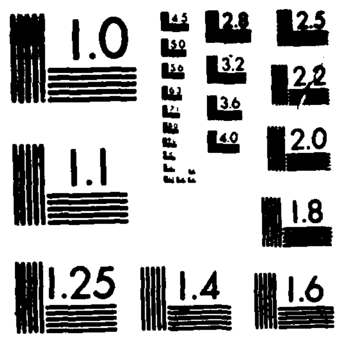
AD-A183 604 UNAMACE (UNIVERSAL AUTOMATIC MAP COMPILATION EQUIPMENT) 1/1
SOFTWARE IMPROVEMENTS(U) ARMY ENGINEER TOPOGRAPHIC LABS
FORT BELVOIR VA F R NORVELLE 08 OCT 86 ETL-R102

UNCLASSIFIED F/G 8/2 NL

END
9-87
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A183 684

DTIC FILE COPY

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

DTIC SELECTE AUG 2 4 1987 S D

(2)

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) R-102	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION USAETL / 6b. OFFICE SYMBOL (If applicable) CEETL-LO	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Fort Belvoir, VA 22060-5546	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION / 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

UNAMACE SOFTWARE IMPROVEMENTS

12. PERSONAL AUTHOR(S)

F. Raye Norvelle

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Research	FROM ____ TO ____	8 October 1986	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	UNAMACE systematic errors correlation

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

At the request of the Defense Mapping Agency (DMA), the U.S. Army Engineer Topographic Laboratories (USAETL) performed an analysis of the Universal Automatic Map Compilation Equipment (UNAMACE) software to determine why certain systematic errors occur in the elevations produced by the compilation process. The analysis uncovered (1) three significant software errors, (2) a deficiency in part of the UNAMACE algorithm and (3) a severe reduction in compilation speed compared to the original design speed. The software has been changed to eliminate the software errors, to improve the accuracy of estimating the elevation of points to be correlated and to increase the compilation rate by a factor of two.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL F. DARLENE SEYLER	22b. TELEPHONE (Include Area Code) 202-355-2647 / 22c. OFFICE SYMBOL CEETL-LO

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

UNAMACE SOFTWARE IMPROVEMENTS

F. Raye Norvelle
U.S. Army Engineer Topographic Laboratories

Commander and Director
U.S. Army Engineer Topographic Laboratories
ATTN: ETL-CS-I (F. R. Norvelle)
Fort Belvoir, VA 22060-5546

ABSTRACT

At the request of the Defense Mapping Agency (DMA), the U.S. Army Engineer Topographic Laboratories (USAETL) performed an analysis of the Universal Automatic Map Compilation Equipment (UNAMACE) software to determine why certain systematic errors occur in the elevations produced by the compilation process. The analysis uncovered (1) three significant software errors, (2) a deficiency in part of the UNAMACE algorithm and (3) a severe reduction in compilation speed compared to the original design speed. The software has been changed to eliminate the software errors, to improve the accuracy of estimating the elevation of points to be correlated and to increase the compilation rate by a factor of two.

INTRODUCTION

The Universal Automatic Map Compilation Equipment (UNAMACE) was developed in the 1960's to extract elevation data automatically from stereopairs of photographs using electronic correlation techniques. The system has been well documented over the past 20 years and, for brevity sake, a description of the UNAMACE will not be repeated herein.

One characteristic of the UNAMACE that does need description is that the elevation data produced via the correlation method sometimes contains systematic errors. That is, the system tends to "dig" in on one side of a hill and "float" over the other. The original UNAMACE design has undergone various hardware and software modifications over the years to improve performance, reliability and maintainability. Very little has been achieved, however, in regard to isolating and removing the systematic errors.

At the request of the Defense Mapping Agency (DMA), the U.S. Army Engineer Topographic Laboratories (USAETL) began an investigation in March 1984 to determine the causes of the systematic errors and to recommend corrective action. The study was completed in November of 1985. Towards the end of the study, it was discovered that previous

software modifications had resulted in a severe reduction in compilation speed compared to the original design rate. Consequently, a second phase was started in order to implement a "fast version" of UNAMACE software. This phase was completed in April 1986.

In the following sections of this paper, the deficiencies found in the software are described along with an explanation of the necessary corrective action. The results of the software corrections and improvements are illustrated by comparing elevation profiles before and after the changes are implemented.

INVESTIGATION

The scope of the work effort initially involved investigation of both the hardware and software aspects of the UNAMACE. No hardware improvements could be identified, except those that required major redesign. Consequently, the scope was limited to investigation of the software for the purpose of detecting errors and to determine if algorithm changes could be implemented to improve correlation accuracy.

It was assumed initially that the UNAMACE software and algorithms were implemented correctly and that the systematic errors in elevation data were due primarily to terrain related problems such as poor-scene content, too large a raster and "footprint" on the ground, no raster shaping as a function of terrain slope, etc. The method used initially in this investigation was, therefore, to implement the means to minimize terrain-dependent problems and test the effect of the changes.

The tests showed no real improvement regarding correlation accuracy--the improvements offered were more or less in the "noise" range. Those improvements that were found were usually offset by disadvantages in other respects. In order to conduct the tests, the software had to be studied and changed. In this process several software errors were detected and, subsequently, the emphasis shifted from algorithm testing to the detection of additional software errors.

RESULTS

The work performed in this investigation resulted in improvements that can best be described under the following headings:

a. Software Errors

b. Algorithm Enhancements

c. Added Capabilities

d. Increased Compilation Speed

Software Errors. Three major errors were found in the UNAMACE software. Two have a direct bearing on the accuracy of the elevation data and the third affects only the operator's perception of how well the UNAMACE performs during compilation. A discussion of the errors is given in the following sections.

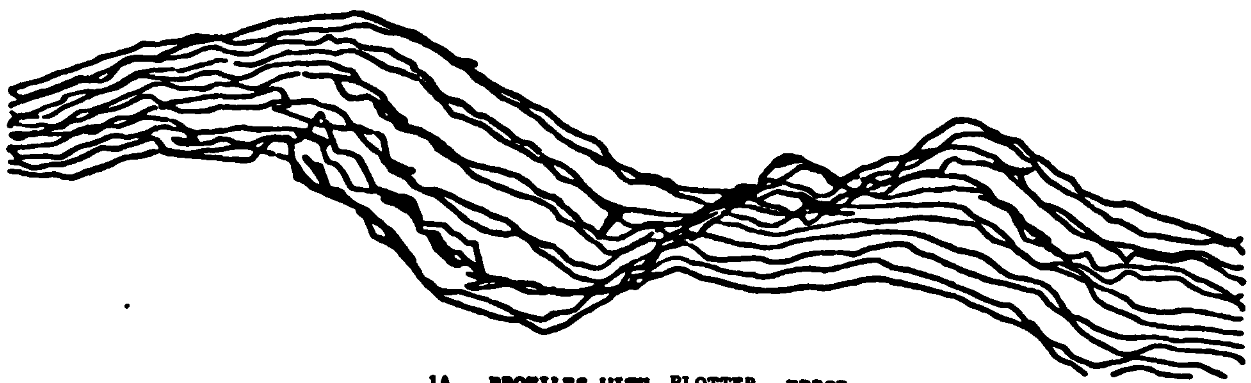
Graphics Plotter Error. A graphics terminal is used with the UNAMACE to provide the operator with a visual plot of the profile data on a point-by-point basis. To the casual observer, the profiles show that the UNAMACE correlation process "digs" below positive slopes and "floats" above negative slopes when profiling in the positive Y-direction. The effect reverses when profiling in the negative direction. The net result, as shown in Figure 1A, is typified by a "pairing" of adjacent profile lines.

The obvious pairing effect is not in the recorded elevation data but is due, instead, to an error in the routine that plots the data on the terminal. The plot routine is active continuously on a priority basis. When the priorities are such that the plot routine is allowed to execute, the routine is supposed to plot the last computed elevation at the last Y position along the profile. The Y position is then updated by the profiling increment, and computations proceed for the next point. As it turns out, the timing is such that the Y-profile position gets updated to the next position before the plot routine becomes active. Consequently, the "last" elevation (Z) actually gets plotted at the "next" Y position. The error in positioning the elevations reverses direction between positive and negative profiles and, therefore, adjacent profiles are shifted two profiling increments relative to each other. This could be misinterpreted by the casual observer as the "floating" and "digging" effect.

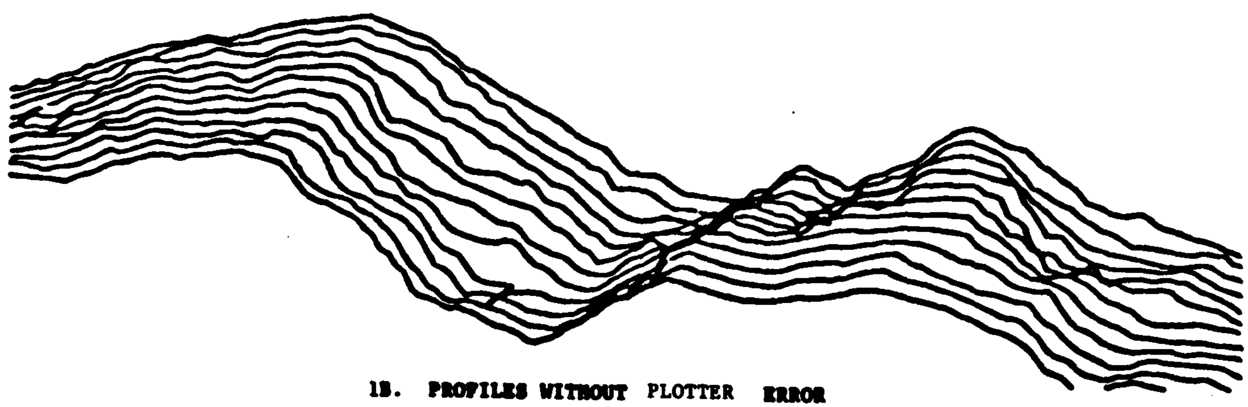
The error in the plot routine is always present but not always noticeable. On very long profiles, for example, the scale of the plot on the terminal will be small and, therefore, a two-increment shift will not be very obvious. Also, the error is not noticeable in very flat terrain. Figure 1B shows how the profiles appear after the plot error is removed.

Raster Shift Error. At the end of the correlation process on each point, the current UNAMACE software computes the x- and y-raster shifts that were imparted to the rasters in order to remove x-parallax. In the current configuration of the software, there is no reason to perform this computation. It appears that the computation was part of some other algorithm approach that was not removed when the current software configuration was implemented.

The computed raster shifts are used subsequently (and erroneously) to modify the desired table coordinates of the "next" point to be correlated. After the modifications are made, the raster shift values are then reset to zero. The new table coordinates (which



1A. PROFILES WITH PLOTTER ERROR



1B. PROFILES WITHOUT PLOTTER ERROR

FIGURE 1. EFFECT OF GRAPHICS PLOTTER ERROR

now include the raster shift error) are transmitted to the hardware in order to drive the tables to the next point on the photographs.

In a typical case the tables will have to be moved approximately 250 microns to get to the next point. The software, however, allows only 210 microns of movement for each table movement command. Consequently, a 250-micron change to the table positions is executed in two passes (210 + 40). On the first pass, the table positions contain the raster shift error. But since the error is reset to zero after first being used, the second pass does not include the error and the tables are positioned correctly.

The problem that occurs is that, under some circumstances, only one pass is necessary to position the tables and the shift values remain as errors in the table positions. This leads to a false x-parallax removal during subsequent correlation and, in turn, erroneous elevation computations.

Figure 2 shows a test profile from a panoramic stereomodel on which two segments (A and B) have been marked for reference purposes. Segment "B" represents a condition where a model movement of 250 microns requires table movements of less than 210 microns. Consequently, the raster shift error is present in this segment. This condition occurs primarily on steep terrain slopes facing away from the camera and at significant "look" angles in the model area. It also occurs more often with panoramic geometry since the scale of the image decreases with larger scan angles and, therefore, the table movements will be much less than the nominal 250-micron model movement.

Figure 3 shows the results of running positive and negative profiles over segments B with and without the raster shift error present in the software. The solid and dashed lines in the figure show the profile results of the current UNAMACE software which includes the error. The solid line is the positive profile and is higher than normal because the x-parallax removed at the previous point is added into the table positions. The dashed line is the negative profile and is lower because negative x-parallax error was added in. The displacements between the two reach a magnitude of 13 meters. The shaded area on the figure represents the difference between the positive and negative profiles when the raster shift error is removed from the software. The improvement is obvious by inspection.

Frame Shaping Error. During the correlation process, the UNAMACE detects x-parallax between the scanned images and increments the ZL counter to update the original estimate for the elevation of the point. Each update to the ZL counter (made in terms of the Z-model coordinate) imparts a proportionate change to the raster

9

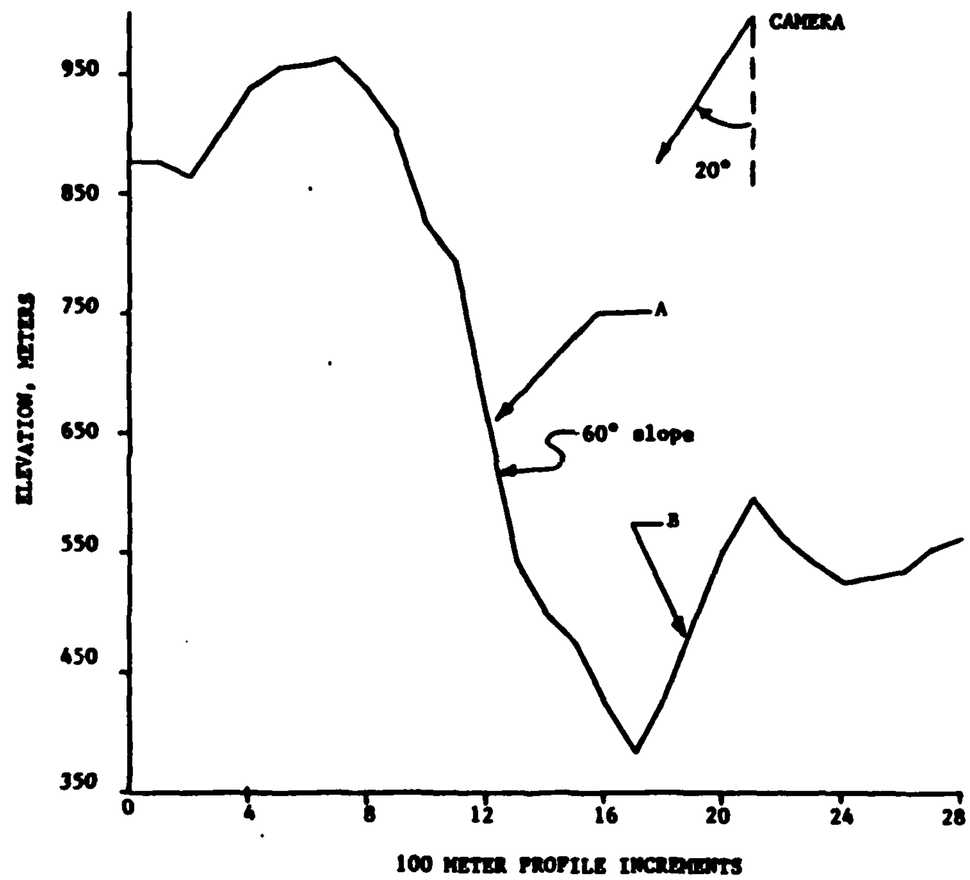


FIGURE 2. PANORAMIC TEST PROFILE

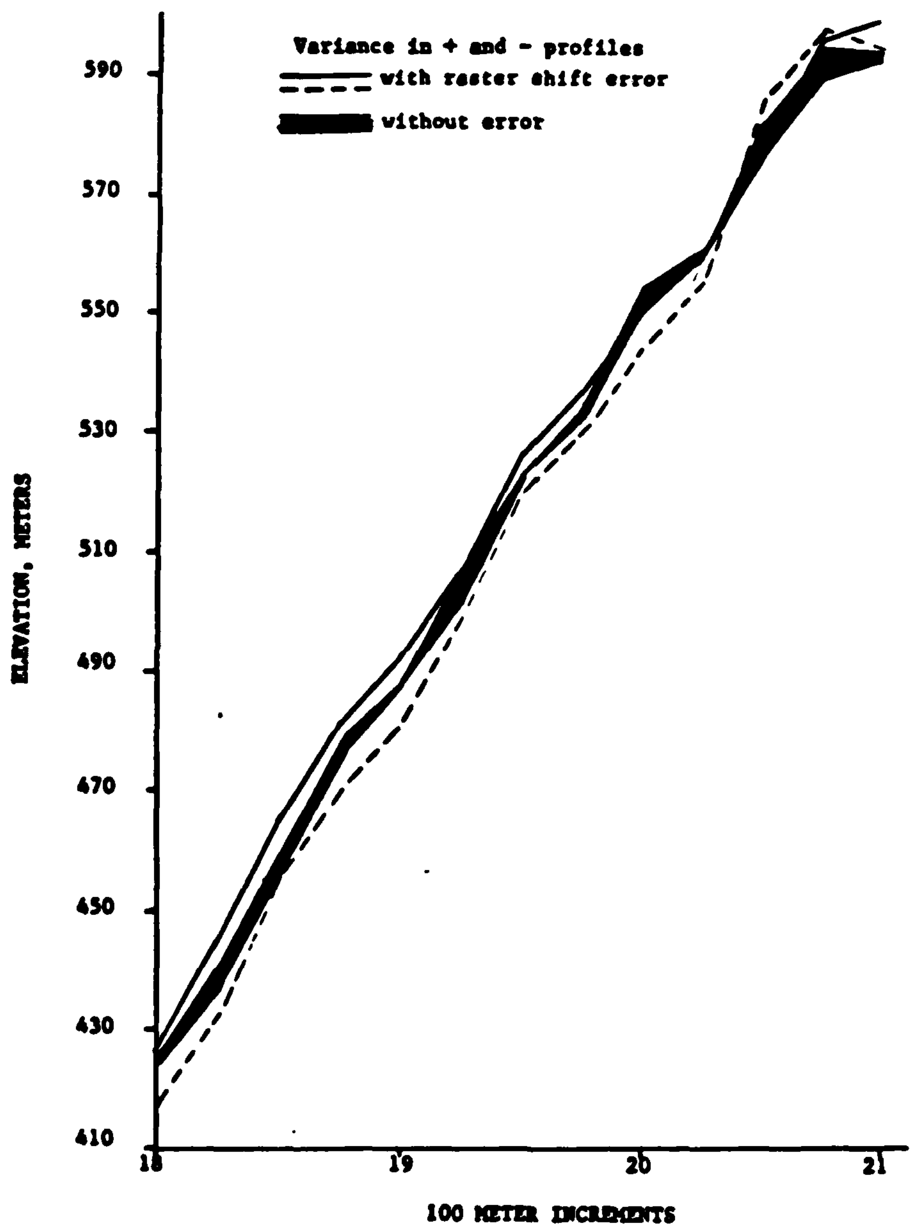


FIGURE 3. EFFECT OF RASTER SHIFT ERROR, SEGMENT B

positions in both the x- and y-photocoordinate directions. As the updated Z-value approaches the correct value, the rasters converge on the correct image point.

The rate at which the rasters change with each change to the ZL counter depends on the magnitude of the coefficients computed by the software and stored in the hardware. The coefficients are derived by differentiating the projective equations in terms of changes to the X-, Y- and Z-model coordinates:

$$dx = K_1 dX + K_2 dY + K_3 dZ \qquad (1)$$
$$dy = L_1 dX + L_2 dY + L_3 dZ$$

where:

dx,dy -----changes to the photocoordinates
dX,dY,dZ --changes to the model coordinates
K,L's -----partial derivatives of the projective equations.

The K and L terms with subscripts 1 and 2 are used to shape the raster while the K_3 and L_3 terms are used to shift the rasters on the photograph for corresponding changes to the dZ (ZL counter). A set of K and L terms are derived for each photograph.

For frame type geometry, the shaping parameters are further modified to take into account the orientation of the photos on the tables and film shrinkage. An attempt was made in the original software to simplify the computation of the coefficients by using only the major terms of the interior orientation and deleting terms that caused only imperceptible changes to the raster positions. Unfortunately, an error was made in the simplification effort which has the effect to setting the L_3 coefficient to near zero. The result is that when the ZL counter is incremented to remove elevation error, the rasters are shifted in the x-direction but not in the y-direction. As a consequence, the elevation correction is made at the wrong model point.

Figure 4 shows the geometrical effect of the error in the y-raster shift term. The DZ value is the error in estimating the elevation at point "B". During correlation, corrections to the DZ error should make the rasters converge to the images of point "B". Since the y photochange is prohibited by the error in the raster shifting term, the elevation actually derived will be that of point "C". The magnitude of the elevation error is a function of the terrain slope (α), the model "look" angle (β) and the error in the estimate (DZ) of the elevation of the point to be correlated. If YINC = 25 meters, $\alpha = 30$ and $\beta = -20^\circ$, the separation between the positive and negative profiles will be 7.8 meters. These errors give rise to the perception that the UNAMACE "digs" and "floats" on adjacent profiles.

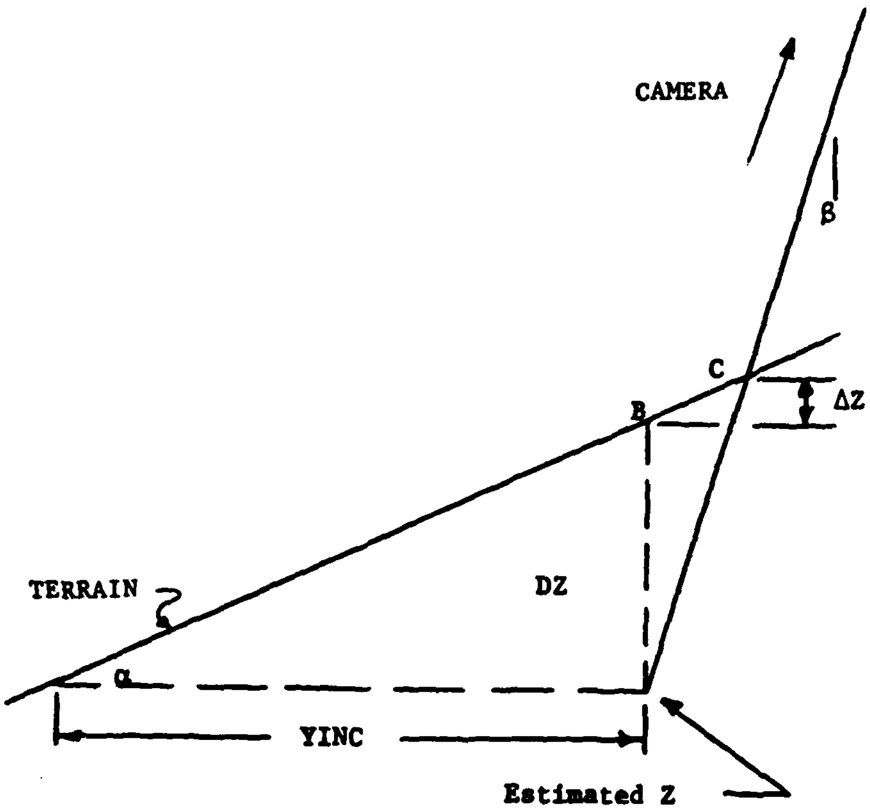


FIGURE 4. GEOMETRY OF FRAME SHAPING ERROR

Algorithm Enhancements. The errors discussed above result in profile errors that are either real or perceived. Other factors, referred herein as "inherent correlation weaknesses," can also cause systematic correlation errors that give rise to the "digging", and "floating" effect. These weaknesses are described in the following section which, in turn, is followed by a section that describes an enhancement to the UNAMACE algorithm to help minimize the adverse affects of inherent weaknesses.

Inherent Correlation Weaknesses. The UNAMACE uses the elevation derived at the previous point in a profile as an estimate for the elevation of the next point to be correlated. Consequently, for a positive profile, the estimated elevations on positive slopes are always below ground and are always above on negative slopes. The reverse is true on negative profiles.

There are various inherent factors that tend to prevent the correlation process from successfully correcting the estimated elevation via the correlation process. Consequently, points estimated below the terrain surface, tend to stay below the surface. Those estimated above tend to stay above. Since the direction of the estimates reverse on positive and negative profiles, the result is that the profiles inherently tend to "dig" and "float" depending on the slope and direction of profiling.

Some of the inherent factors that prevent successful correlation are listed below:

a. Poor-scene content in the photos

b. Too much x-parallax to remove

c. Too little time for correlation

d. Large raster

e. Line correlation

Poor-Scene Content. "Poor-scene content" is probably the worst condition affecting correlation. If the rasters are void of detail (such as in forest areas) there will be no basis for the removal of x-parallax. If the correlation process is on a positive profile and climbing a positive slope, the estimated elevation for "next" points will be low. If no x-parallax is removed, the computed Z's will be low giving rise to the "digging in" effect on positive slopes. If after a few points, the scene content improves, the correlation process may recover provided x-parallax is not too great.

X-parallax Removal. The x-parallax factor becomes important when it gets too large to be removed during a normal correlation period. It is possible, for example, that the parallax is so large that the two rasters are "looking" at two dissimilar areas. That is, a large percent of the raster on the left photo will cover imagery not covered by the raster on the right photo. This could cause a lack of correlation or possibly a diverging situation. Suppose, however, the parallax is only marginally large and that correlation is possible. Then successful correlation depends on how much time the correlation has to remove the large x-parallax.

Correlation Time. The correlator runs continuously but is only "sampled" at discrete periods in order to determine how many counts of the "ZL counter" have been made in order to remove x-parallax. The counts are then converted to meters of elevation (Z). The sample period of the correlator can vary from 14 to 29 milliseconds. Under software control, the correlation process will cease and continue to the next point whenever the ZL counter changes by less than 8 counts or whenever 29 milliseconds has been reached. The procedure is to read the ZL counter after 14, 17, 20 --29 milliseconds to detect a change of less than 8 counts.

Large Raster. The nominal raster size used by the UNAMACE is 500 microns in the y-direction and 1000 in x. On images with scales of 1/100,000, for example, the raster covers approximately 50 X 100 meters on the ground. In most cases, a raster this large in size will include terrain with significant elevation change within its boundaries. As a consequence, the correlator will provide the average elevation of the terrain "under" the raster. Rounded peaks, for example, will have lower elevations while drains are more likely to be too high.

Line Correlation. The UNAMACE is sometimes referred to as an area correlator in that the raster eventually covers a 2-dimensional shape. Even though an area is actually scanned, correlation is performed on individual lines or groups of lines and not on the area as a whole. Consequently, those lines that contribute to x-parallax removal at the start of the correlation period have no further bearing on the solution near the end of the period. The problem this presents is that at any given instance, correlation is based on relative little information, compared to the amount of information actually scanned over the duration of the correlation period.

Minimizing Weaknesses. The above conditions that adversely affect correlation could be minimized significantly if the elevation of the "next" point to be correlated could be estimated with very little

error. It is not possible to compute the "next" elevation without error, but it can be determined more accurately than simply using the previous elevation. The following section describes an improved method for estimating elevation.

Improved Elevation Prediction. The UNAMACE program stores the elevations derived for the previous two profiles in memory. As the third profile is generated, it overwrites the data of the first profile. Meanwhile, the data in the second profile is used to check for unacceptable elevation changes between the second and third profiles. The elevations obtained at the conclusion of each profile are recorded on the disk and, therefore, the overwriting process does not cause data to be lost.

The routine that acquires the elevations from the previous profile for cross-profile checking has been modified to also acquire the elevation in the previous profile that corresponds to the next point in the current profile. This elevation is used as one estimate for the next point to be correlated.

A second estimate for the elevation of the next point is obtained by projecting the slope between the last 3 points in the current profile to the next point on the profile. The elevation obtained by slope projection is combined in a weighted fashion with the elevation of the previous profile to provide the Z-estimate for the next point. Figure 5 shows the geometry of this procedure.

Figure 6 shows the advantages gained by better Z-prediction when profiling segment A of the test profile. The solid line (mostly obscured by the shaded area) is the original UNAMACE profile in the positive direction. The dotted line is the negative profile data. The envelope between the solid and dotted lines represents the error between adjacent profiles. The dark shaded area represents the errors between adjacent profiles when the new method is used to predict the elevation of the next point. The improvement is obvious by inspection.

The envelope between the solid and dotted lines in Figure 6 illustrates the points made previously about inherent correlation weaknesses. That is, even though the positive and negative profiles are essentially identical, terrain conditions can be such that points estimated above ground tend to stay above and points below stay below. The discrepancy is minimized, however, by providing a more realistic method for predicting the elevation of the next point.

Figures 1A and 1B, alluded to previously, illustrate the effect of the graphics plotter error. Actually, Figure 1A was obtained using the current UNAMACE production software, but 1B was obtained

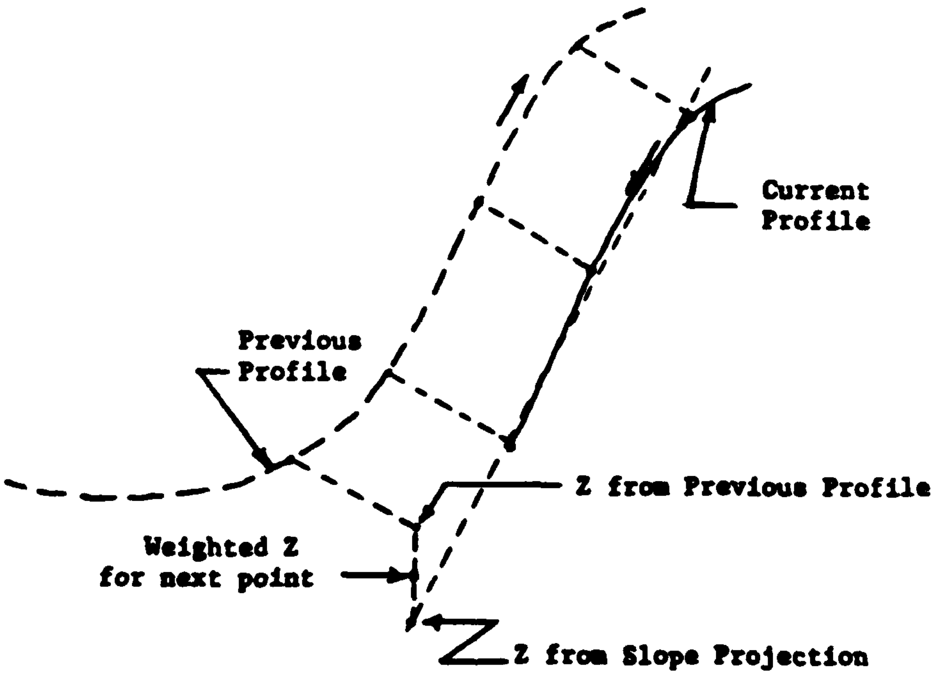


FIGURE 5. GEOMETRY OF NEW ELEVATION PREDICTION SCHEME.

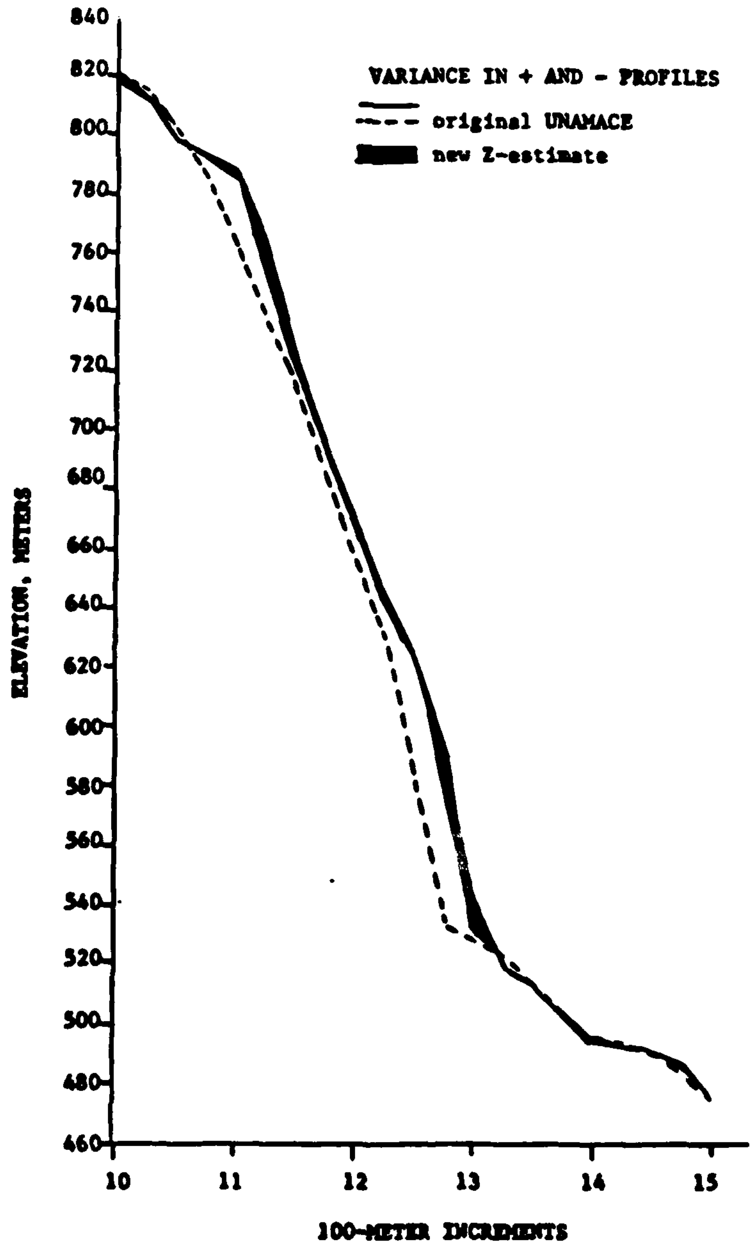


FIGURE 6. EFFECT OF NEW Z-ESTIMATE ON PROFILING ACCURACY SEGMENT A.

using the software that contains corrections for all errors discussed above and the new Z-prediction scheme. The "pairing" of lines in 1A is due to the plotter error as discussed before. The dark, retraces of lines in 1A were caused when correlation was lost, the processed "backed-up", and the operator intervened to plot the profiles manually. Notice that the original software "backed-up" frequently while the new version did not. The difference is that the new Z-prediction scheme used in 1B kept the Z errors small and, therefore, allowed successful correlation more often in the difficult areas.

Added Capabilities. There were only a couple of areas where new capabilities (or tools) could be added to the UNAMACE program to make operation somewhat easier for the operator. The current software uses practically all of the available memory, leaving very little for improvements beyond those already alluded to.

One new capability was added that allows the operator to perform semiautomatic profiling. Currently, the operator can profile manually by using a joystick to raise or lower the "floating dot" while using another control to advance in discrete steps along the profile. The new capability allows the operator to select a mode where the model point advances automatically in the profiling direction and at a speed selected by the operator. The operator needs only to adjust the elevation of the reference mark ("floating dot") using either the trackball or the joystick control.

An additional change was made to the software that involves speed control. With the current code, the operator can press the "slow" button to reduce the compilation rate and hopefully, improve correlation. Actually, pressing the "slow" button simply means that a longer time is taken for the tables to drive from one point to the next, and no extra time is given to the correlation process. The code has been changed so that "slow" now translates directly into a longer correlation period on each point and, frequently, to improved correlation results.

Increased Compilation Speed. The operations performed by the UNAMACE during each point-loop time can be summarized as follows:

a. compute x,y photocoordinates

b. drive tables to computed photocoordinates

c. correlate

d. compute Z correction to estimated elevation

e. check accuracy of Z

f. store updated elevation

g. increment x & y ground position & return

The current UNAMACE software performs the operations in a sequential manner. The correlation step is totally hardware dependent and, consequently, the software is made to wait (do nothing) for 14 to 29 msec while x-parallax is removed from the photographs via the correlation process. Since the hardware runs independently of the software, it is possible to use the current 14-29 msec wait period to perform the computations for the "next" point while the hardware correlates on the "current" point. The result is a tremendous savings in point-loop time and a much faster rate of compilation. Figure 7 shows a relative comparison of the point-loop times for the original UNAMACE approach and a "fast version".

In order to compute the x,y photocoordinates of the "next" point, it is necessary to know the X- and Y- ground coordinates of the next point and its estimated elevation (Z). The X and Y ground coordinates are always known because they are "input" values. The estimated Z is not well known, however, until correlation is completed on the "current" point. In order to implement the "fast version", it must be assumed that the estimated elevation of the next point is the same as the estimated Z of the current point. There is no error caused by this assumption, but it could cause a condition where more elevation correction is required of the correlation process than the hardware can handle. To avoid this problem, the computed photocoordinates for point N+1 are updated as a function of the Z correction obtained on point N and then used to drive the tables to the "next" point (N+1). This scheme can be expressed mathematically as follows:

$$x_0 + \Delta x_0 = f_1(X,Y,Z_0) + \frac{dx}{dZ}(\Delta Z_0) \qquad (2)$$

$$y_0 + \Delta y_0 = f_2(X,Y,Z_0) + \frac{dy}{dZ}(\Delta Z_0) \qquad (3)$$

where:

x_0, y_0-------- the x and y photocoordinates of ground point X, Y and the first approximation Z_0.

$\Delta x_0, \Delta y_0$--------the corrections to x_0 and y_0 as a function of the correction ΔZ_0 to the first approximation of Z_0.

While correlation is performed on the current point, the x_0, y_0 values are computed for the next point using X, Y and Z_0 as the ground coordinates. The term ΔZ_0 is obtained after correlation is completed on the current point. It is then used with dx/dZ and dy/dZ to compute corrections to x_0 and y_0 based on a better (updated) estimated elevation ($Z_0 + \Delta Z_0$).

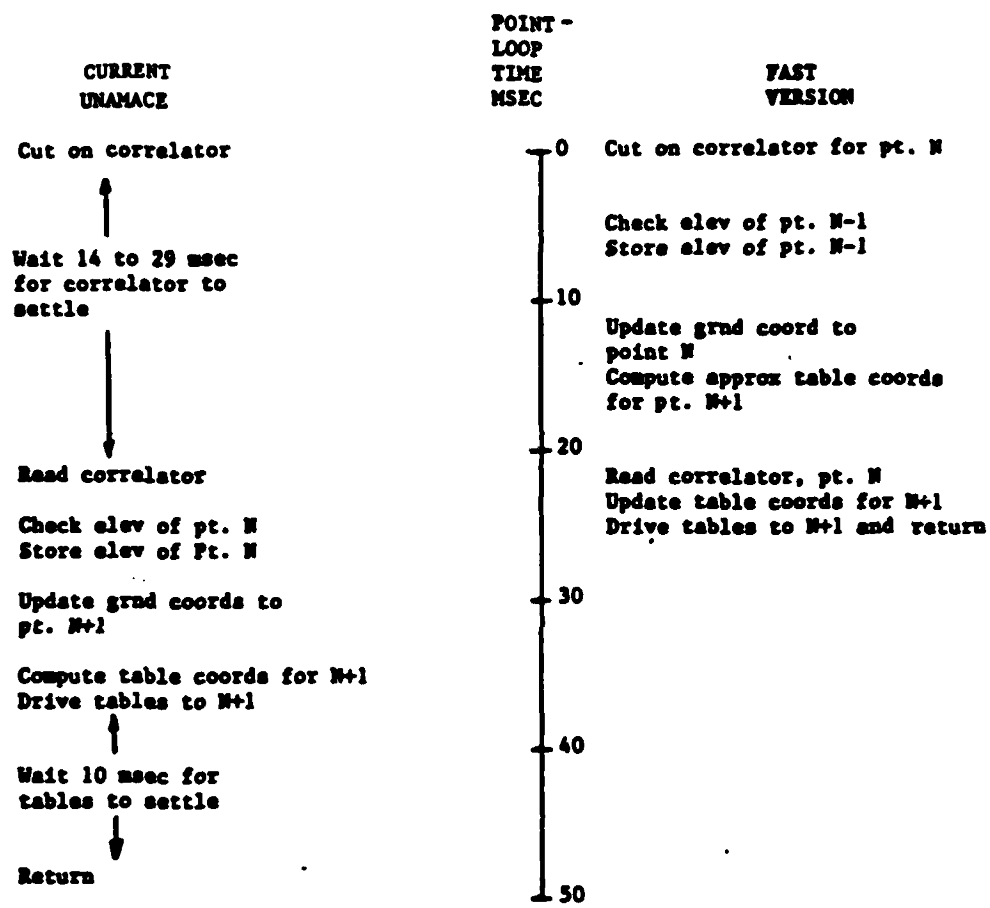


FIGURE 7. COMPARISON OF POINT-LOOP TIMES

The dx/dZ and dy/dZ terms are obtained by differentiating the projective equations relative to changes to the ground elevation Z. These terms are currently computed by the UNAMACE software and are used for raster shifting during the correlation process.

The increased speed of compilation, compared to the original UNAMACE software, is not a fixed quantity because the point-loop times vary somewhat depending on how long it takes for the correlator to settle (remove detectable x-parallax). In general, however, the increase will be about double on typical stereomodels.

DISCUSSION

During the initial stages of this investigation, numerous profiles were compiled on the UNAMACE simply to gain some understanding of how the system worked and what problems existed. The most noticeable problem was that the profiles were "digging" and "floating" as demonstrated by the profile plots on the graphics screen. Later it was determined that the plot routine for the graphics screen was in error and that the actual observed profile data probably was correct. The question raised, then, is whether the widespread belief that the UNAMACE "digs" and "floats" is based on casual observance of an erroneous plot on the graphics screen or on an evaluation of actual profile data. The stigma attached to the UNAMACE is probably due to both.

Analysis of the actual elevation data from the UNAMACE shows that the "digging" and "floating" problem is not always present and should not be considered a foregone conclusion. The problem is mostly present when the scene content of the images is poor and, therefore, the "inherent correlation weaknesses" discussed previously become the major contributor to systematic error. "Poor-scene" content is characterized by areas of imagery that do not contain sufficient terrain detail to provide adequate x-parallax detection. Also, "poor-scene" content could mean that the variance in terrain heights within the boundaries of the rasters is too large to permit accurate elevation determination for the center (reference mark) of the raster area.

The estimated Z, along with the known X- and Y-ground coordinates of the point to be correlated, are used to compute the predicted table coordinates of the point on the images. The UNAMACE uses the computed Z of the previous point as an estimate for the next point. This assumption is only accurate in flat terrain. However, the hardware is capable of accumulating corrections large enough to accommodate serious errors in estimated Z values. This doesn't

mean, though, that the scene content is sufficiently high to provide adequate signal for x-parallax removal. If poor-scene content is present, a Z value estimated low or high will tend to remain low or high giving rise to the systematic "digging" and "floating" effect on all but flat terrain.

The new method of Z prediction used in the "fast version" of the UNAMACE software should significantly reduce the "digging" and "floating" caused by scene- and terrain-related problems. Its advantage is that a more realistic Z is estimated and, therefore, requires less x-parallax removal. Consequently, less x-parallax signal (and scene content) is needed in order for the process to converge to a solution. The new Z-prediction method will not only provide better accuracy, but will also require less "backing-up" and less operator intervention.

CONCLUSIONS

1. Two major software errors exist in the current production version of the UNAMACE software that adversely affect profiling accuracy under some typical conditions.

2. An error exists in the software that is used to plot profiles on the graphics monitor.

3. Profile accuracy can be improved by the implementation of a new method for extrapolating the estimated elevation for the next point to be correlated.

4. An additional, semiautomatic mode of profiling can be implemented which is better than the current manual approach.

5. The speed of compilation can be increased from 20 to 40 points per second with no loss in correlation accuracy.

RECOMMENDATION

It is recommended that the software changes made as part of this investigation, (and implemented in a fully functional, disk-resident program) be used to replace the current production version of UNAMACE software.

END
9-87
DTIC